Matching Technology Developments to System Requirements

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ABSTRACT

In the field of telecommunications, the applications for GaAs MMIC's beyond 2000 will include today's drivers such as Cellular and Portable Telephones, Direct Broadcast Systems and CATV distribution, but also the emerging markets of multimedia satellite communications, broadband Wireless Services, and high bit rate optical fibre systems. These latter systems use millimetre wave carrier frequencies, typically ranging from 10 GHz to 80 GHz.

The full paper will look at the requirements which have shaped the Philips' GaAs technologies available today as well as what will be required for the future. Examples will be given of both the system requirement, circuit solution and the technology push.

BROADBAND WIRELESS SYSTEMS :

Multipoint Distribution systems are being used for the local point to multipoint broadcast at 28 GHz and 42 GHz. Initially providing conventional TV services, the system is tailored to be able to provide video on demand, telephone as well as Internet connections. Today BWS systems implement mainly discrete components and features the DBS frequency around 12 GHz as first IF, thus allowing the use of standard Ku band components for the second down conversion.

However the trend towards more compact implementations and lower power consumption will lead designers to use more integrated functions, such as a single chip receiver with image rejection. Also the Tx path will benefit from the integration of the up-converter and LO doubler, the power amplifier remaining separate.

Figures 1,2 and 3 show an example of a mobile high data rate transceiver developed as part of an European project (see reference 1, B. Byzery et al.). This is a good example of high data rate at millimetre wave frequencies using an architecture and frequency compatible with the 40.5 to 42.5 GHz BWS systems. The requirement for these mobile or fixed high data rate systems are essentially the same as for BWS.

To meet the market requirements Philips introduced the first generation 0.2 µm process which is currently used for the LNA's in BWS systems. The second generation ED02AH process has an improved noise figure and has been used as described above to make the complete front end. In parallel with this the pressure on pricing and manufacturability has led Philips to work on Coplanar designs and Flip technologies - this will provide the third generation products.

The transmit function requires a high performance power process, where we have the possibility to fabricate power amplifiers meeting te efficiency and output power requirements using the smallest possible surface area. Large, expensive, circuits are not appropriate to this market. To meet the requirement we have developed a 0.15 µm pseudomorphic HEMT technology with a 'T-gate' structure. An example of the measured output power for a large (6x100 µm) transistor is shown in figure 4. The measurements are non-pulsed, with the output matched for maximum output power, the input is not matched.

SATELLITE COMMUNICATIONS :

Projects are numerous that aim at building an airborne infrastructure to provide a global multimedia network service. Beyond pioneers Iridium and Globalstar that will offer the first worldwide telephony networks before the turn of the century, programmes like Skybridge and Teledesic will offer ultra high data rate routes for any multimedia applications. Figure 5 shows the rapid acceleration in the number of satellite launches so as to have systems in place early next century.

Philips' activity in this area has been to work with its partners in chip design and fabrication and also to Qualify the same PHEMT processes as for the commercial BWS systems for space borne use. This market has led us, for example, to develop a high reliability via hole process compatible with the requirements of space borne use

HIGH DATA RATE OPTICAL FIBRE SYSTEMS :

The fabulous growth in data transmission, fuelled by Email and Internet, has led to a saturation of the global telecommunications networks. This has in turn led to the deployment on a large scale of new fibre as well as the introduction of WDM in existing networks. Figure 6 shows the number of Km's of fibre installed per year. GaAs is today extensively used in 2.5 Gb/s (OC48),and in WDM (4x2.5 Gb/s) systems. The market for 10 Gb/s (OC192) is developing rapidly with new fibre being laid allowing 10 Gb/s transmission.

The first generation 2.5 Gb/s products are being manufactured using our standard MESFET processes. The move to higher data rates and the requirement for better sensitivity and lower supply voltages has led Philips to develop low noise 0.5 µm and 0.2µm PHEMT processes, with a mixed mode option for the 10 Gb/s.

The PHEMT technology with its low knee voltage and superior noise capability is ideally suited to the single supply 3.3 V 2.5 Gb/s requirement while maintaining the 0.5 µm gate will allow the move to high volumes and lower prices to be met. Figure 7 shows the measured performance of a Transimpedance Amplifier designed for 10 Gb/s using the 0.2 µm enhancement depletion mode process.

TECHNOLOGY ROADMAP :

Philips has built its millimetre-wave base line process on a pseudomorphic HEMT technology, using low cost high throughput MOCVD epitaxial layers. This same base line technology is used, with appropriately changed modules, for low noise, high power or high speed digital. Consideration has always been given equally to the need for high throughput, low cost and at the same time high performance processes.

Care has also been taken to re-use as many processing steps as possible when developing a new technology - this modular approach drastically reduces the development time, simplifies the process qualification and gives the designer access to a large data base of models and statistics from the start.

In parallel to this activity we are continuing our space qualification programmes, investigating new packaging methods (including flip chip), new design techniques as well as extending our range of processes to meet the demand for high volume, low cost, advanced GaAs MMICs.

REFERENCES

1. Ka Band GaAs MMIC Chip Set for a 40 GHz Mobile Broadband Front End, B. Byzery et al. M&RF97, Wembley October 1997

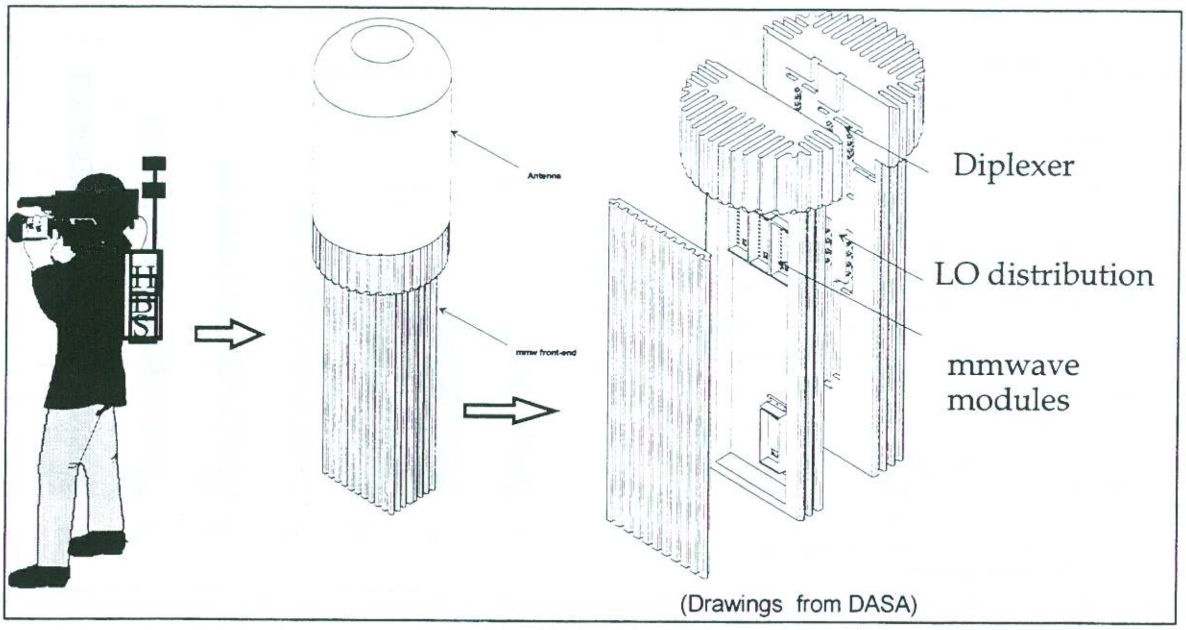

Figure 1. An example of a mobile high data rate transmission system at millimetre wave frequencies

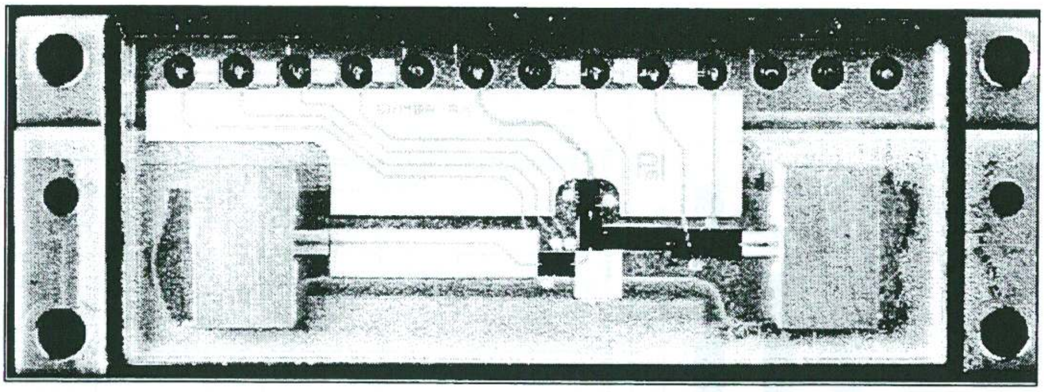

Figure 2. The MMICs mounted in the receiver

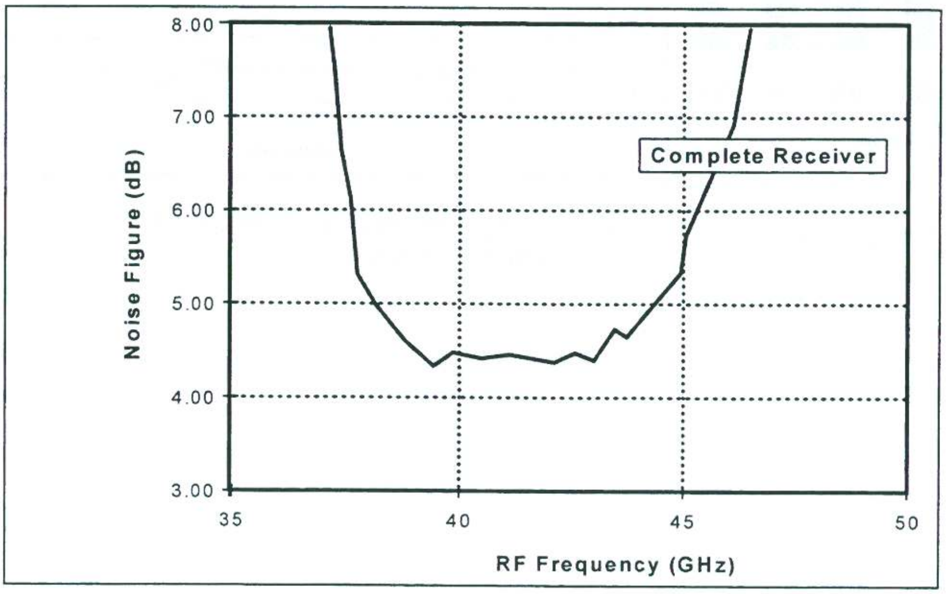

Figure 3. Measured noise figure versus frequency performance of the complete receiver.

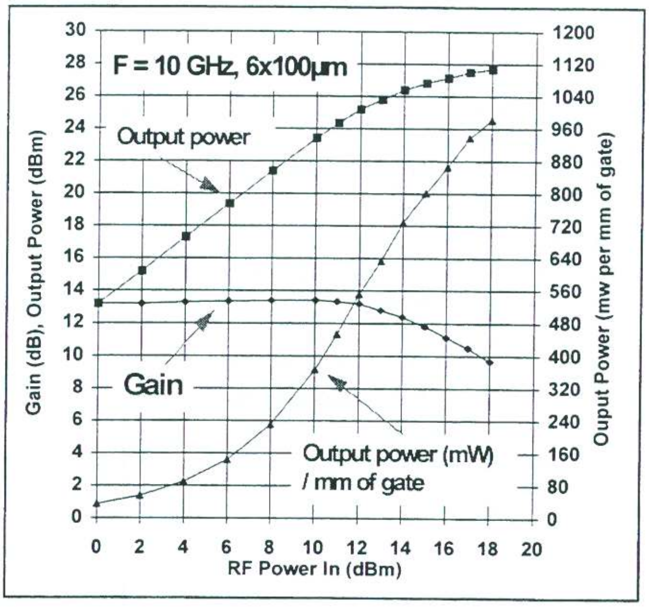

Figure 4. On wafer measurements of the 0.15 µm PHEMT power process (single 6x100 µm FET).

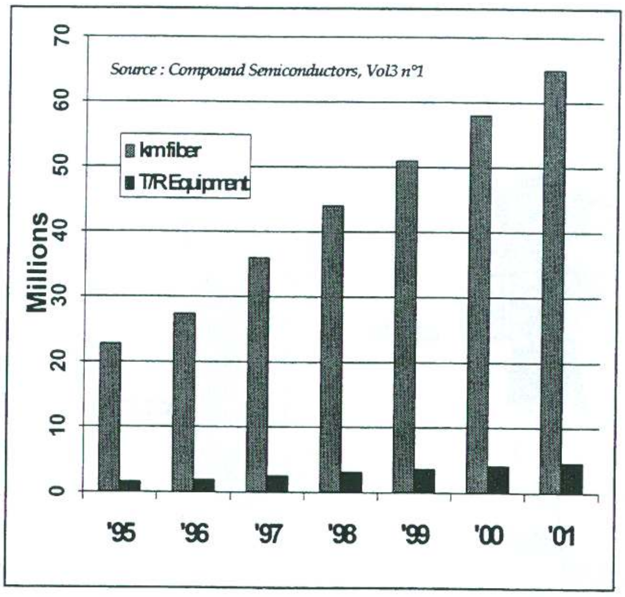

Figure 6. Number of Kilometres of installed fibre optic cable per year.

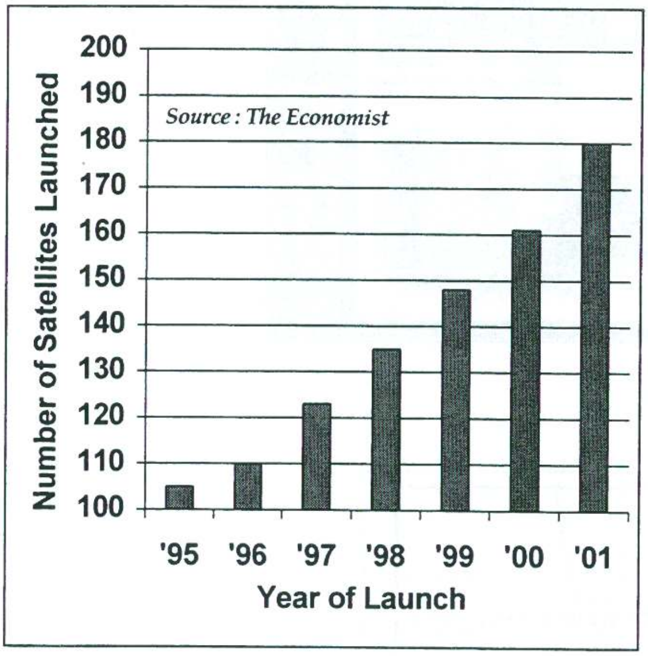

Figure 5. Number of Satellite Launches per year.

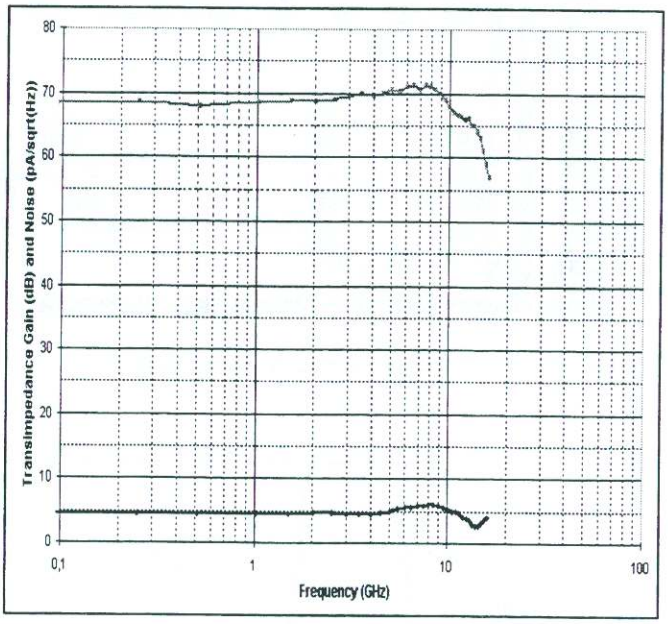

Figure 7. Frequency response of a 10 Gb/s MMIC Transimpedance amplifier